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Depth Profiling of Magnetic Tape with the Aid of SIMS

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Depth profiling was done for eight kinds of atomic ions such as $^{12}C^+$, $^{14}N^+$, $^{16}O^+$, $^{27}Al^+$, $^{35}Cl^+$, $^{52}Cr^+$, $^{56}Fe^+$, and $^{59}Co^+$ from magnetic tapes with the aid of SIMS. Data for four samples were compared with each other. Results were still qualitative, however, useful information was obtained; antistatic agent is more abundantly distributed near surface than inside of the samples, the amount of antistatic agent is negatively correlated with dynamic resistance, etc.

KEY WORDS: SIMS/ Depth profiling/ Magnetic tape/ Antistatic agent/

INTRODUCTION

Depth profiling technique is promising in the study of surface and interface in polymeric materials. Secondary Ion Mass Spectrometry (SIMS) is also applicable to the depth profiling of polymeric systems[1),2)], besides X-ray Photoelectron Spectroscopy (XPS).[3)~8)] SIMS is more advantageous than XPS in two points; 1) the maximum detectable depth in XPS is limited to 5 nm due to the escape depth of photoelectron, while there is no limit in SIMS, and 2) the information is obtained for an arbitrary depth in SIMS, while it is obtained in the integral from the surface to the desired depth in XPS. The second point leads to better resolution in SIMS than in XPS. On the contrary, XPS depth profiling can be done nondestructively, while SIMS one is destructive. This is the advantage of XPS than of SIMS.

In this paper SIMS depth profiling of magnetic tapes will be reported. The profiling was done from one surface (magnetics) to the opposite surface (base); total thickness of the tapes is much larger than 5 nm. It means SIMS is exclusively applicable method to the purpose.

EXPERIMENTAL

1. *Samples*

Four samples were used for measurements. All of them were magnetic tapes of the grade of T-120 for video tape recorders. They were commercially available and were manufactured by four different companies. Base of these samples was polyester. Thickness of the samples were tabulated in Table I.

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Table I. Thickness of the samples used in this paper/μm

Sample	Total	Magnetic Layer
A	18.67	4.77
B	19.67	4.72
C	19.49	4.69
D	18.82	4.57

2. *Instrument*

Depth profiling was done with a SIMS A-DIDA-3000 equipped by Atomika Technische Physik GmbH. Ar^+ ions were bombarded from the primary ion gun. Ar^+ was used to prevent any chemical reaction. The primary ion beam was accelerated with a voltage of 3 kV and its beam current was 50 nA. Such a low current was used to prevent any change (thermal and chemical) of surface. Furthermore, the sample was covered with by electron shower compensating for the charge-up. During measurements the pressure in the sample chamber was kept at less than 4×10^{-7} Pa. Measurement was done from one side of surface (magnetics) to the oppssite side(base) for each sample. Arrival to the opposite side was confirmed by the formation of pin-hole after measurement.

RESULTS AND DISCUSSION

In Figures 1, 2, 3, and 4 are shown the time dependence of the intensities of secondary ions from the samples A, B, C, and D, respectively. In order to avoid the confusion due to crowdness of experimental points, each figure was devided into (a) and (b), in which the intensities of $^{35}Cl^+$, $^{52}Cr^+$, $^{56}Fe^+$, and $^{59}Co^+$ were compiled in (a),

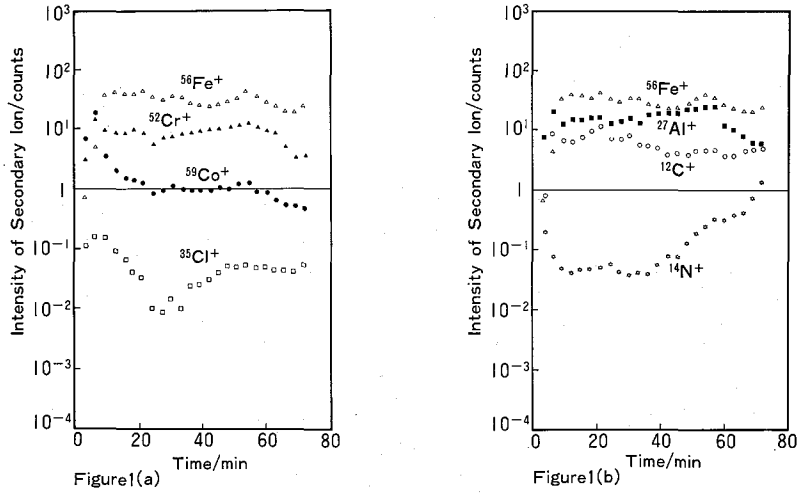

Figure 1. Time dependence of the intensities of scondary ions, $^{35}Cl^+$, $^{52}Cr^+$, $^{56}Fe^+$, $^{59}Co^+$, $^{12}C^+$, $^{14}N^+$, and $^{27}Al^+$ from the sample A.

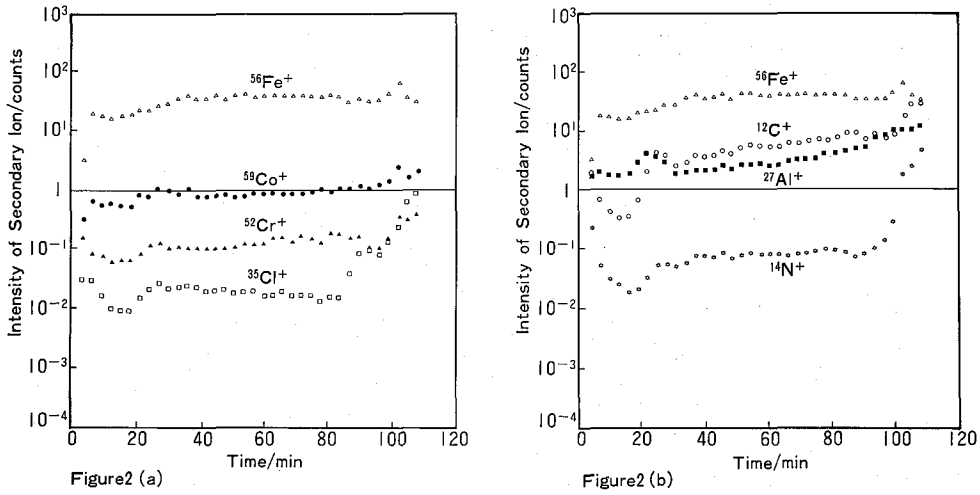

Figure 2. Time dependence of the intensities of secondary ions, $^{35}Cl^+$, $^{52}Cr^+$, $^{56}Fe^+$, $^{59}Co^+$, $^{12}C^+$, $^{14}N^+$, and $^{27}Al^+$ from the sample B.

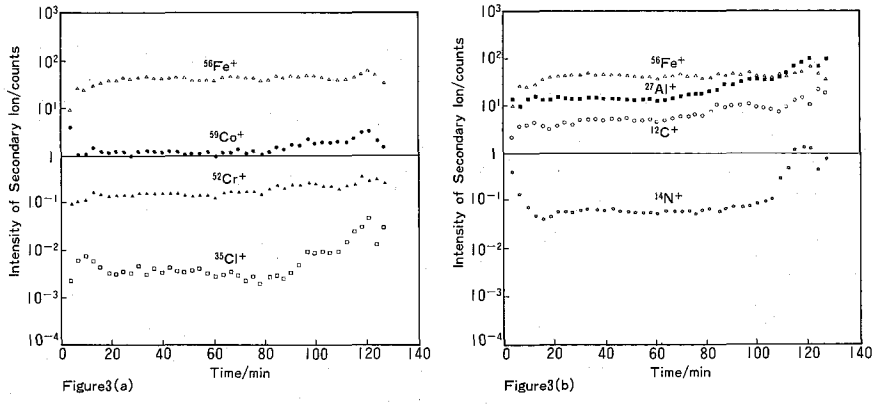

Figure 3. Time dependence of the intensities of secondary ions, $^{35}Cl^+$, $^{52}Cr^+$, $^{56}Fe^+$, $^{59}Co^+$, $^{12}C^+$, $^{14}N^+$, and $^{27}Al^+$ from the sample C.

while $^{12}C^+$, $^{14}N^+$, $^{27}Al^+$, and $^{56}Fe^+$ were in (b). For the convenience of comparison, intensities of $^{56}Fe^+$ were compiled both in (a) and in (b). Intensities of secondary ions are much affected by the existence of oxygen.[9] This is recognized as oxygen effect. In order to remove this oxygen effect, all intensities of secondary ions were normalized by the intensities of $^{16}O^+$ in this article.

Generally speaking, the samples A and D are close with each other, and B and C are, from the comparison of the depth profiling patterns of these four samples. More precisely,

1) Cl is more abundantly distributed in the region close to magnetics in the sample A. This trend is explainable with a term of the distribution of antistatic agent which includes Cl.

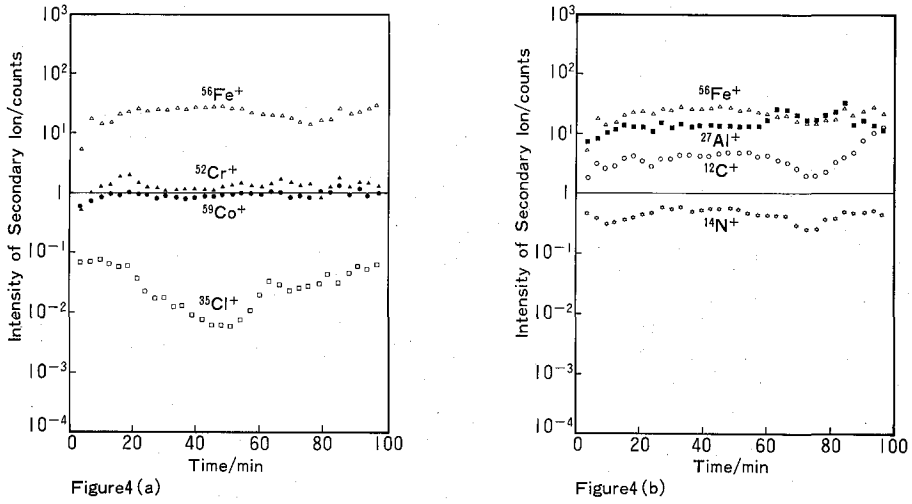

Figure 4. Time dependence of the intensities of secondary ions, $^{35}Cl^+$, $^{52}Cr^+$, $^{56}Fe^+$, $^{59}Co^+$, $^{12}C^+$, $^{14}N^+$, and $^{27}Al^+$ from the sample D.

2) Cl is more abundantly distributed in the opposite side (base) in the samples B and C, while Cl is in both sides in the sample D.

3) The time required for depth profiling is the shortest in the sample A in spite of almost equal thickness in these four samples. This finding may be due to the effectiveness of the antistatic agent.

4) Metallic elements, Al, Fe. Cr. and Co are localized in the area close to the surface (magnetics) in the samples A and D, while they are almost equally distrituted in the whole range of the samples B and C. A small amount of these elements is observed even in the inside of the samples A and D. It is still unclear whether these traces are due to actual migration to inside or poor resolution in the measurements.

5) An increase of N is observed corresponding to the decrease of the above metallic elements in the inside of the whole samples.

6) Among physical properties, both of static and dynamic friction constants are not correlated with any finding from this SIMS experiments.

7) Dynamic resistance is well correlated with the intensity of Cl close to surface.

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